

Maximizing Processing of Low-Grade Bauxite to Fulfil the Specialty Alumina Demand

**Kaushal Gupta¹, Rama Nahak², Purva Nandha³, Santanu Dey⁴
and Muthukumar Tharumar⁵**

1. Head, Technology & Process, Specialty Alumina

2. Head, Alumina Operation

3. Area in Charge, Bayer Process Technical

4. Red Area in Charge, Alumina Operation

Hindalco Industries, Belagavi, India

5. Area Manager, Mining

Nalco Water India, Kolkata, India

Corresponding author: kaushalkishore.gupta@adityabirla.com

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Abstract

Bauxite is the most common source and a critical raw material for hydrate and alumina production through a consistent and controlled process. The Belagavi Alumina Refinery, renowned globally for its specialty alumina hydrate production, was originally designed to process high-grade bauxite with a Tri-Hydrate Alumina (THA) content of 40 % and a reactive silica content of 3 %, sourced from captive mines. Following the depletion of these mines, the refinery transitioned to using purchased bauxite (imported and domestic), incorporating a blend of 20-30 % low-quality bauxite to maintain a minimum feedstock quality of 37–38 % THA. Under the current global challenges in bauxite availability, the Belagavi refinery was further forced to increase the proportion of low-grade bauxite (THA 34 %, Reactive Silica 4.5 %) in its feedstock wherein the quality variations in loads received from mines posed significant challenges in addition to design limitations of its conventional clarification vessels across the mud circuit. The processing of such bauxite has introduced significant technical challenges in the clarification process, leading to persistent issues in the filtration of decanter overflow across the Kelly filters. To mitigate these challenges, extensive laboratory evaluations were conducted to assess applications of various chemical additives to enhance process efficiency and to apply the same at plant scale. Through these rigorous collaborative efforts, the Belagavi refinery has been capable to adapt, now processing 100 % low-grade bauxite and meeting the demand for specialty alumina without compromising product quality. This paper details the methodologies and process optimizations deployed to enable the effective utilization of low-grade bauxite, ensuring a sustainable and efficient refinery operation.

Keywords: Specialty Grade Alumina, Tri-hydrate Alumina.

1. Introduction

The Belagavi Alumina Refinery of Hindalco Industries Limited is globally recognized for its consistent production of high-quality specialty grade alumina (VAP and Super VAP). Originally commissioned to process high-grade bauxite from captive mines, the refinery was optimized for a feedstock containing approximately 40 % Trihydrate Alumina (THA) and less than 3 % reactive silica. However, following the depletion and subsequent closure of these mines, the refinery was compelled to diversify its raw material base, gradually shifting towards both imported and domestically sourced bauxites.

Further compounding the challenge was the abrupt disruption in imported bauxite supply during August–September 2024 due to external factors at the supplier's end in Guinea. As a result, the

refinery had to pivot rapidly to 100% domestic purchased bauxite, triggering a range of operational bottlenecks and quality control concerns. One of the most critical constraints has been processing low-grade bauxite with higher reactive silica and lower available alumina content, which affects key Bayer process areas, especially clarification and filtration in conventional thickeners and Kelly filter setup.

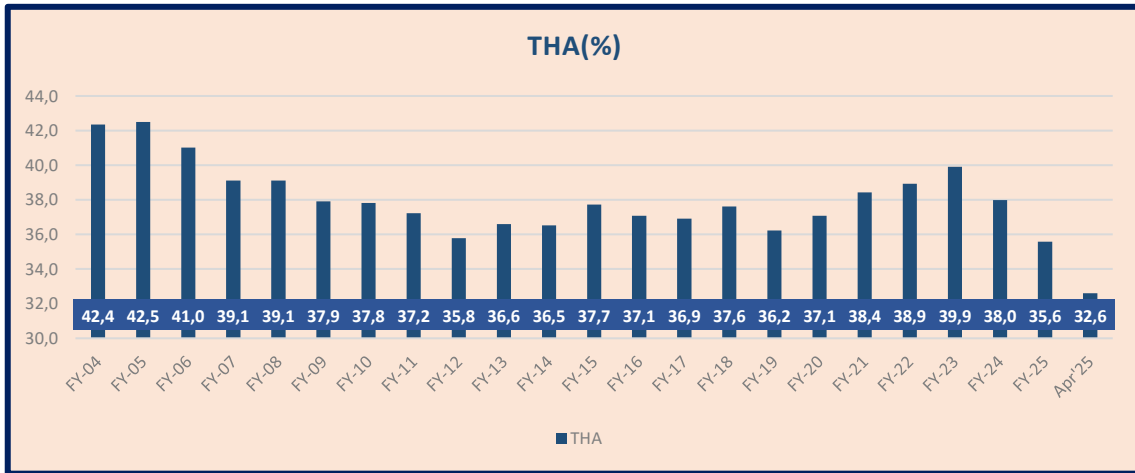


Figure 1. Feed bauxite THA from last 20 years.

As the refinery progressively increased the proportion of low-grade bauxite in its feed blend (as shown in Figure 1), a distinct shift in process behaviour was observed – most notably in the clarification and filtration sections. Flocculation used that had worked efficiently with high-grade or blended bauxite were no longer yielding desirable results. Overflow liquor from settlers exhibited elevated solids content, which began overloading the security filtration stage and significantly reducing the filtration capacity of the Kelly press filters.

Despite the absence of visible cloudiness in the settler overflow, fine suspended particles continued to persist in the clarified liquor. These ultrafine solids were consistently impacting the filtration rate at the security filtration stage. Their presence led to premature clogging of filter media in the Kelly press filters, reducing effective liquor throughput and sometimes increasing mud content in the filtrate.

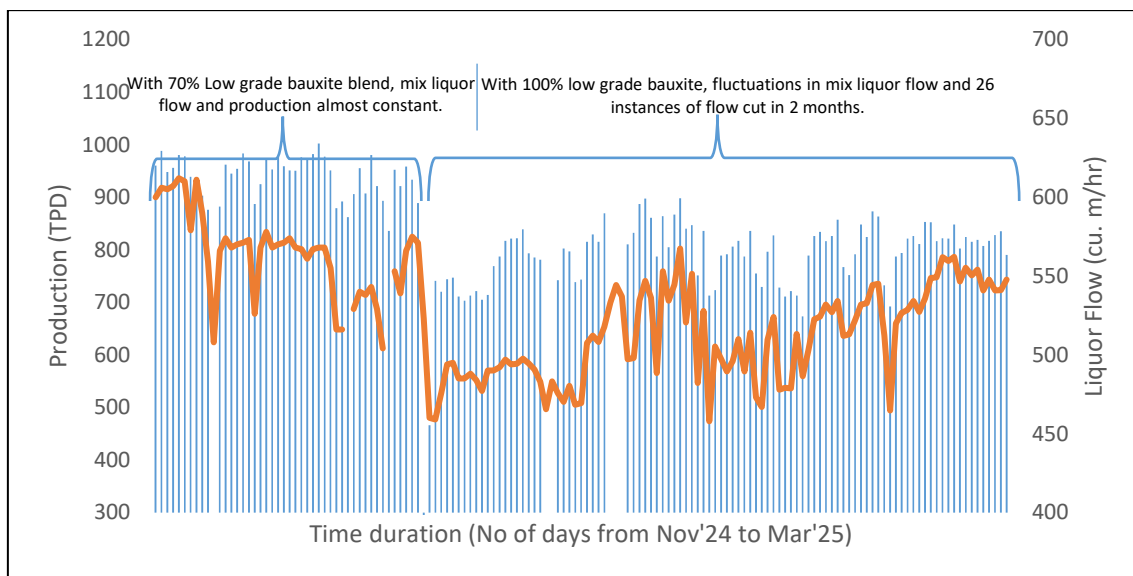


Figure 2. Production rate vs mix liquor flow.

This disruption led to inconsistent Pregnant liquor availability, hampering downstream production rates as shown in Figure 2. It became evident that a deeper understanding of the interaction between changed bauxite chemistry and the process additives was required. With this context, a focused laboratory evaluation was undertaken to explore operational strategies to restore and enhance process stability and production rate despite charging 100 % Low grade bauxite.

2. Laboratory Trial

Laboratory investigations and pilot trials to re-evaluate the process for the new bauxite regime were carried out. A wide array of flocculants was explored for compatibility and effectiveness in improving slurry settling, liquor clarity, and filtration rates. The objective of lab trial was to evaluate the performance of specific chemical additives in improving the filtration rate of settler overflow liquor – a key bottleneck observed in the Kelly filter operations and settling rate in settler.



Figure 3. Comparison of N-9779 and combination of N-9779 and N-85700.

To address the filtration and settling challenges posed by low-grade bauxite, preliminary laboratory experiments (settling jar tests as shown in Figure 3) were initiated using various flocculant systems [1]. These trials aimed to optimize the flocculation mechanism and improve liquor clarity and filtration flux. The tests involved the use of two flocculants – N-9779 (Polyacrylates) [2] alone and a combination of N-9779 with N-85700 (Flocculant for Hydrate Tray Thickener: Engineered Bio polymer) – to evaluate their influence on settling and filtration behaviour. Based on the optimal combination of dosages applied in both the feed pipe and feed well, a plant-scale trial was successfully initiated and improvement in floc formation was experienced in refinery.

After successful implementation of N-85700 flocculant in the plant, noticeable relief was observed in terms of improved settling behaviour. A reduction in mix liquor flow cuts indicated better mud compaction and clarity at the settler underflow, contributing to overall circuit stability. However, despite these improvements, a corresponding increase in filtration rate was not evident – though importantly, the rate remained steady without further decline. This partial relief prompted the need for additional enhancement. To further push the limits of filtration performance, a new set of laboratory evaluations was initiated using a laboratory scale filtration setup. These trials focused on screening additional chemical additives, including filtration aids, to identify optimal combinations that could deliver tangible gains in filtration flux and reduce downstream load on security filtration units.

To assess the impact of chemical additives on the filtration performance of settler overflow liquor (SOF), a systematic laboratory test was conducted under controlled conditions. The following procedure was employed:

1. Sample Collection

Settler overflow liquor was collected directly from the plant settler outlet to ensure representative process conditions. Simultaneously, the standard TCA used in the plant was collected from the security filtration area. Multiple aliquots of the SOF (Settler Overflow) were dispensed into clean, clearly labelled 200 mL Nalgene bottles to serve as test units for different experimental conditions.

2. Additive Dosing and Conditioning

Known concentrations of filter aids (FM-482 and FM-485) were prepared as 0.5 % w/v solutions using distilled water. These additives were then dosed into the respective Nalgene bottles containing 200 mL of SOF. Along with the filter aid, a fixed volume (7 mL) of TCA was added to each bottle to replicate field conditions. The bottles were gently swirled and allowed to stand undisturbed for a reaction period of 10 minutes, ensuring sufficient interaction between the liquor and additives.

3. Filtration Setup

A laboratory-scale filtration apparatus was prepared using a filter flask and funnel assembly fitted with a 5-micron pore size filter paper. The setup was checked for integrity and positioned to enable rapid filtration measurements.

4. Filtration and Timing

Following the 10-minute reaction time, each test bottle was gently shaken to re-suspend any settled material. The liquor was then immediately poured into the funnel, and a stopwatch was started simultaneously. The time taken for complete filtration of the 200 mL liquor was precisely recorded. This duration was used to calculate the filtration flux (L/h), which served as a key performance metric.

5. Filtrate Collection and Clarity Assessment

The filtered liquor (filtrate) was collected in a clean container for clarity evaluation. Visual clarity was initially assessed, and further quantification was performed using turbidity measurements or suspended solids analysis.

This method enabled a direct comparison of filtration performance across different additive dosages and types under uniform conditions, simulating field performance in a controlled environment.

A total of five tests were conducted using 0.5% w/v solutions of the additives prepared in distilled water. In each test, 200 mL of SOF liquor was filtered under controlled temperature conditions (~97°C) with a fixed TCA dosage of 7 mL, while varying the dosage of FM-482 and FM-485 between 5 ppm and 10 ppm

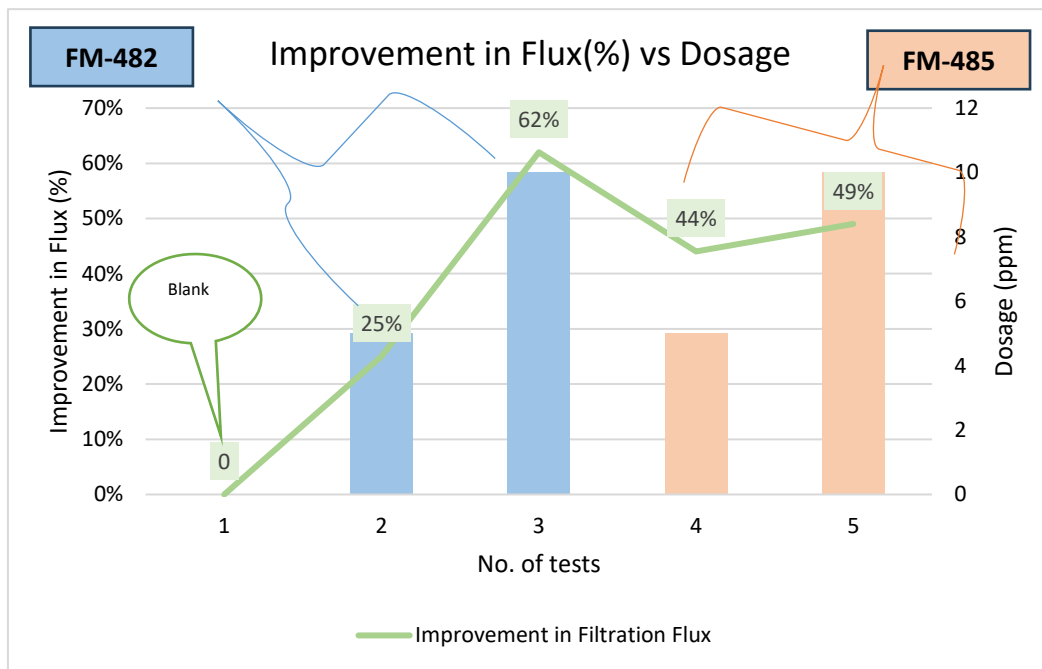


Figure 4. Results of filtration test work with FM-482 and FM-485.

The results (as shown in Figure 4) clearly demonstrated that both FM-482 and FM-485 significantly enhanced filtration performance compared to the blank on top of TCA addition (for all tests) based on the effectiveness of FM-485 it was selected for plant-scale validation trials.

3. Plant Trial

Following the encouraging outcomes of laboratory evaluations, plant-scale implementation was undertaken to validate the effectiveness of the optimized flocculant and filtration aid system in overcoming clarification and filtration challenges arising from low-grade bauxite processing. The trial focused on improving overflow clarity, reducing filter load, and stabilizing overall liquor handling to achieve consistent production rates.

In the plant, a combination of flocculants dosages – N-9779 dosed into the settler feed pipe as well as feed well – was processed, alongside continued use of TCA as the filtration aid. FM 485 was also tested to further enhance filtration performance. These chemical interventions were carefully introduced across the clarification circuit to mimic the controlled conditions established during laboratory studies.



Figure 5. Plant jar tests.

A key success indicator was the marked improvement in settler overflow clarity. Prior to the trial, the overflow solids carried over to the filtration stage were erratic and significantly above desired levels, often causing rapid blinding of the Kelly filters. Post-trial, a notable improvement was recorded—the standard deviation of SOF (settler overflow) solids reduced from 150 to 78 mg/L, indicating improved consistency and stability in the clarification process. This directly translated to reduced load and stress on the Kelly filtration unit.

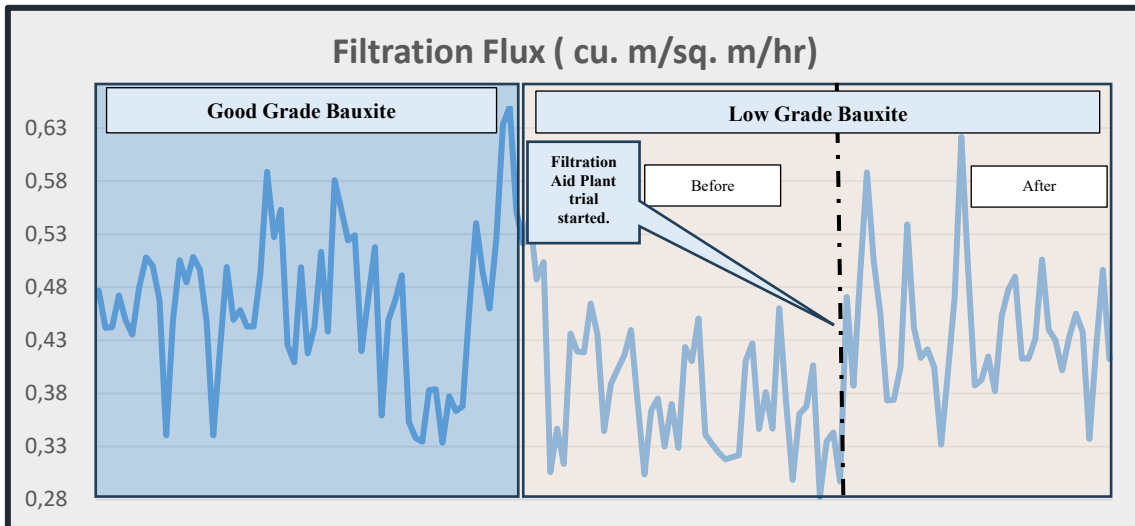


Figure 6. Improvement in filtration flux.

With a cleaner overflow stream, Kelly press filters experienced less fouling and downtime, improving their availability and operating efficiency. This allowed for increased liquor throughput as shown in Figure 6, aligning closer to the refinery’s design capacity. Previously, high solids carryover had constrained the amount of liquor that could be filtered, limiting overall liquor throughput and causing fluctuations in daily production rate. Below Figure 7 demonstrates utilisation (No. of filters in service) of Kelly filters as per availability in a day before and after starting of plant trial. Utilisation came down after addition of Filtration aid and thus availability increased for effective maintenance.

As a result of the trial, consistent and stable production rates were achieved – a significant improvement over previous operations, which were hindered by solids-related bottlenecks. The ability to handle higher volumes of liquor consistently contributed to a more robust process, even under the constraints imposed by a non-ideal, low-grade bauxite blend.

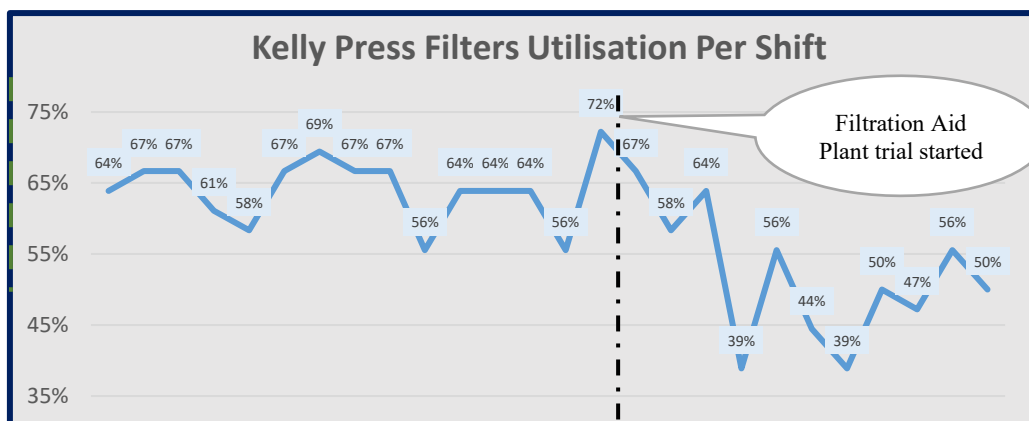


Figure 7. Trend of Kelly press in service per shift out of 12 available filters.

This successful plant-scale demonstration reaffirmed the lab findings and validated the approach of using targeted chemical and process interventions to restore control, reduce variability, and sustain high-quality specialty alumina production in a challenging raw material regime.

5. Conclusion

The Belagavi Refinery's transition to processing 100 % low-grade bauxite presented considerable operational challenges, particularly in clarification and filtration due to increased fines. Through a combination of systematic laboratory investigations, pilot-scale evaluations, and carefully designed plant trials, the refinery successfully re-engineered its process to adapt 100 % low grade Bauxite.

The introduction of optimized flocculant systems (N-9779 and N-85700), in conjunction with appropriate filtration aids on top of TCA, significantly improved overflow clarity and filtration rates. These interventions reduced the standard deviation of overflow solids, stabilized the clarification process, and increased the availability and performance of Kelly filters. As a result, the refinery regained consistent liquor throughput and achieved steady production rates of high-quality specialty alumina, including VAP and Super VAP products. A major innovation in process was seen as new filtration aid as additive was identified and dosing point was identified to sustain the filtration during processing low grade bauxite to cater specialty alumina demand.

Through collaborative efforts and targeted process improvements, the refinery demonstrated that even a conventional design can adapt to 100 % domestic, low-grade bauxite while maintaining stringent product quality and operational stability. This achievement supports consistent performance and reflects a strong commitment to long-term sustainable mining and responsible resource utilization.

6. References

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